Guns versus Butter

A MULTISECTORAL APPROACH TO MILITARY EXPENDITURE
AND GROWTH WITH EVIDENCE FROM GREECE, 1960-1993

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Current conventional wisdom suggests that military expenditure may affect economic growth through the creation of additional aggregate demand, the whole host of spin-offs that result from military spending, the possible reduction of investment, and the displacement of talent from the most dynamic sectors of civilian production. Earlier empirical studies on the subject have reported conflicting research findings, attributed to the use of cross-sectional analysis, sample variations and differences in specificational choices, time periods examined, and databases used. These considerations point to the need for case-specific studies using time-series data for individual countries. This article investigates the growth-defense relationship in the case of Greece over the period from 1960 to 1993. Results show that the annual output growth rate in Greece is negatively affected by the size of the defense sector, as measured by real military expenditure. They indicate that the post-1974 threat of war facing Greece as well as the oil-price shocks of the 1970s have retarded economic growth in this country.

Since Benoit's (1973) seminal study of the relationship between military expenditure and economic growth, no clear agreement has emerged about the nature and extent of the growth effects of this expenditure. High or increasing military expenditure levels have been identified with both good and poor economic performance, and statements of each position have been accompanied by plausible justifications.

Proponents of military expenditure justify it not only on the grounds of national security and stability but also in economic terms. In this context, if aggregate demand is initially inadequate relative to potential supply, an increase in the demand of the defense sector leads to more efficient capacity utilization, which increases the profit rate and ultimately stimulates investment and growth (Deger 1986). In addition, the defense sector is often the first to come into contact with modern technology and can train its personnel in handling sophisticated equipment. This experience can then be transmitted to other sectors of the economy (Benoit 1973, 1978).

The basic criticism against military expenditure is that it represents a significant opportunity cost (United Nations 1982). First, government expenditure in general

exhibits lower rates of measurable productivity increases (Benoit 1972). Second, there is usually a trade-off between military expenditure and civilian investment due to the relatively inelastic capacity of the capital goods industries (Smith 1980) and the difficulty associated with any effort to increase the total fund of savings in the economy (Deger 1986). Third, if growth is export-led, military expenditure can lead to a serious displacement of capital and talent from the most dynamic sectors of civilian production to military production (Chan 1985).

Evidently, the answer to whether military expenditure aids or hinders growth must be in theory and history, with statistical analysis used to back up theoretical considerations. However, the empirical literature on the subject is far from conclusive. Several studies have indicated positive net benefits of military spending (Benoit 1973, 1978; Kennedy 1974; Dixon and Moon 1986; Alexander 1995), but others have concluded that the overall net effect is negative (Deger and Sen 1983; Deger and Smith 1983; Leontief and Duchin 1983; Lim 1983; Faini, Annez, and Taylor 1984; Deger 1986; Gyimah-Brempong 1989). The diversity in the conclusions drawn must be attributed to the following reasons.

Use of intercountry cross-section analysis. A great deal of skepticism in relation to cross-country regressions is shared by many investigators. Levine and Renelt (1992) acknowledge the sensitivity of the results to the set of conditioning variables. Evans (1995) discusses econometric problems, which stem from the heterogeneity of slope coefficients across countries. Lee, Pesaran, and Smith (1996) show that convergence tests obtained from cross-country regressions are likely to be misleading because the estimated coefficient of the convergence term contains asymptotic bias. Quah (1993) points out that the technique is predicated on the existence of stable growth paths and shows, using data from 118 countries, that long-term growth patterns are unstable.

Furthermore, cross-country regressions can only refer to the "average effect" of a variable across countries. In the context of causality testing, this limitation is particularly severe because the possibility of differences in causality patterns across countries is likely.

Variations in samples and databases used and the differences in time periods examined.[1] In particular, the results in this area are very sensitive to the samples chosen because one should expect interregional differences in both the intensity and the direction of the growth effects of military spending. For instance, Frederiksen and Looney (1982, 1983) and Looney and Frederiksen (1986) have shown that military expenditure promotes economic growth in foreign resource-rich but not in resource-constrained countries.

Differences in specificational choices adopted. In some previous approaches, "theory entails simply ad hoc justification of the chosen set of regressors, and often variables enter the regressions in ways which have not been theoretically justified, while in

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1. See Chan (1987).

others not enough of reality is captured by the theory" (Alexander 1990, 40). Cappelen, Gleditsch, and Bjerkholt (1984, 363) point out that studies in the area "often rest on weak theoretical underpinnings, do not control for third factors, or do not forward a comprehensive model for explaining growth."

The above considerations suggest that the growth-defense relationship is not uniform across countries. A clearer understanding of this relationship in a particular country requires (a) a model fairly grounded in a theoretical framework and capable of producing explicit results for the direction of the growth effect of military spending and (b) a time-series analysis that may yield deeper insights into the relationship between military expenditure and economic growth than cross-section analysis (Grobar and Porter 1989).

In this context, this study seeks to contribute to current research in the area by investigating the growth-defense relationship in the case of Greece over the period from 1960 to 1993. Greece is chosen for empirical work mainly for two reasons. First, it has constantly ranked among the countries with the highest defense burden (military expenditure as a share of gross domestic product [GDP]) in NATO and in Europe. Thus, in the period from 1970 to 1994, Greece allocated an average of 5.8% to defense compared to a NATO average of 3.3%.[2] Second, the Greek economy is one of the weakest in Europe with persistent economic problems. Between 1980 and 1995, the average annual growth rates of Greek GDP, industrial production, and gross fixed capital formation were 1.3%, 0.5%, and –0.4% compared to the respective averages of 2%, 1.2%, and 1.5% for the European Union (EU). Also, in 1995, Greek GDP per capita was equal to 57.3% of the EU average, a figure considerably lower than that of 1981 (63.7%) or even 1971 (59.7%).[3]

The possibility of the existence of a growth-defense trade-off in Greece has been examined by a number of authors who, however, have attempted to handle indirectly the growth-defense relationship by estimating separately the impact of such an expenditure on certain measures of economic performance (Antonakis and Karavidas 1990a, 1990b; Kollias 1994; Chletsos and Kollias 1995; Balfoussias and Stavrinos 1996). A detailed review of the relevant literature is given in Antonakis (1997). This latter contribution to the growth effects of military expenditure in Greece is the only study that has attempted to handle the issue directly through the estimation of a simultaneous equation model comprising three equations—namely, growth, savings, and defense burden. However, the studies conducted so far have reported conflicting conclusions drawn from the estimation of relationships that do not derive from any coherent growth theory.

This study extends our previous work on the subject and differs from studies for Greece and other countries in several ways. First, from the theoretical point of view, the relationship between military expenditure and growth is examined in the context of the neoclassical production-function framework that provides a formal rationalization for the incorporation of military spending in a growth equation. Although a number of

2. The source is the *SIPRI Yearbooks*, "World Armaments and Disarmament," various issues.
3. The source is *European Economy*, Annual Economic Report for 1995, no. 59, 1995.

authors have used similar models to specify the growth-defense relationship in both cross-country and country-specific studies, they have used either two-sector (civilian and military) or three-sector analysis (military, nonmilitary government, and rest of the economy), thus omitting relevant variables and important linkages in the economies considered.[4] This study sets out to remedy these omissions with the addition of the exports sector to the neoclassical production-function approach. Thus, the theoretical contribution of this study is that it models the impact of military expenditure on economic growth in light of the growth effects of the export performance of the country considered. Given that military expenditure is often foreign-exchange intensive, the hypothesis tested is that if exports positively affect economic growth, then a negative relationship will exist between military expenditure and growth in a foreign resource-constrained country because, with a lack of foreign resources, defense is maintained or increased using scarce foreign exchange taken from alternative productive investment.

However, although economic theory suggests possible equilibrium relationships between variables of interest, it tends to tell us very little about the adjustment processes at work. In fact, all previous studies on the subject have employed simple estimation techniques without attempting to investigate the properties of the individual series involved or to distinguish between long-run and short-run growth effects of military spending. Thus, from the statistical point of view, this study attempts to remedy these omissions by using the technique of cointegration and the general-to-specific methodology, which allows for additional channels through which causality may emerge (Holden and Thompson 1992). It is hoped that the application of the cointegration and the general-to-specific methodology to the extended version of the neoclassical production-function framework will provide a general research agenda for discussing the growth-defense policy choice problem in other countries as well.

THE THEORETICAL FRAMEWORK

The overall net effect of military spending on growth can be analyzed in the context of a model that splits the economy into a number of discrete sectors, and some sectors are thought of as generating externalities that affect the output of other sectors.

Previous studies have shown that government size and exports affect growth in most countries (Ram 1986, 1987). It follows that any properly specified growth model must incorporate variables for both the government and export sectors. Some points of view assign a positive role to the government in the process of economic growth. These include, among others, the following: (a) the role of the government in harmonizing conflicts between private and social interests, (b) prevention of exploitation of the

4. Cross-country studies include Biswas and Ram (1986), Alexander (1990, 1995), and Linden (1992). For country-specific studies, see Atesoglu and Mueller (1990), Huang and Mintz (1991), and Ward and Davis (1991) for the United States; Ward, Cochran, et al. (1991) and Ward, Davis, et al. (1991) for India; Ward, Davis, and Chan (1991) for Taiwan; Cochran and Ward (1991) for Brazil; Ward (1991) for Brazil and India; Davis (1991) for Argentina, South Africa, Korea, and India; and Heo (1996) for South Korea.

country by foreigners, and (c) securing an increase in productive investment. At the other extreme, one point of view suggests that a larger government size is likely to be detrimental to efficiency and growth because, for example, (a) government operations are often conducted inefficiently, (b) the regulatory process imposes excessive burdens and costs on the system, and (c) many of government's fiscal and monetary policies tend to distort economic incentives and lower the productivity of the system. As far as the export sector is concerned, standard propositions of the neoclassical type suggest that good export performance makes major contributions to growth, for example, by (a) offering foreign resources that are necessary for inducing import-led technological change, (b) increasing specialization and expanding the efficiency-raising benefits of comparative advantage, (c) offering greater economies of scale due to an enlargement of the effective market size, and (d) affording greater capacity utilization. The "radical" neo-Marxist positions, on the other hand, suggest that trade between less-developed and industrialized countries, particularly exports from the former to the latter, could constitute an important mechanism through which exploitation of the poorer countries occurs.

The above considerations suggest that a minimum of four sectors is necessary in constructing a model aiming to capture the effect of military spending on growth, without ignoring the effects of other major variables. Thus, the major postulates of the framework adopted in this study are the following.

First, the economy is made up of four sectors, which are mutually exclusive and exhaustive with respect to output. We call these sectors M for military, G for nonmilitary government, E for exports, and R for the rest of the economy.[5]

Second, labor and capital serve as the conventional inputs in all sectors. In addition, and for reasons outlined above, some sectors can be thought of as affecting the output of other sectors, positively or negatively. These effects are referred to as externalities because they are not reflected in market prices. Many different patterns of interaction among the sectors of the model are possible. In this study, we have chosen a structure that is usually considered plausible and useful, according to which the nonmilitary government sector generates externality effects on the remaining sectors, and the military and export sectors generate externalities on the rest of the economy. Apart from the above-mentioned arguments regarding the positive or negative effects of the government and export sectors, the structure of the model incorporates the desirable features that military spending is not autonomous but decided out of a previously fixed government budget (Alexander 1990). In addition, the externality effects of the military and nonmilitary government sectors may differ (Mintz and Huang 1990, 1991). Formally, the production functions underlying the structure of the economy can be written as

$$G = G(L_g, K_g), \tag{1}$$

5. Splitting the economy into a number of discrete sectors is not, in reality, possible, but it does provide a useful abstraction. Some sectors such as the military may, to a considerable extent, stand outside the rest of the economy, but others are much less separate from the whole. However, in setting out a model that posits a number of discrete sectors, we hope to capture the important real interactions.

$$M = M\,(L_m, K_m, G),\qquad(2)$$

$$E = E\,(L_e, K_e, G),\qquad(3)$$

$$R = R\,(L_r, K_r, G, M, E),\qquad(4)$$

where G, M, E, and R represent the outputs of the nonmilitary government, military, export, and rest of the economy sectors, respectively, and the lowercase subscripts stand for the sectoral inputs of labor and capital.

Third, factor productivities may vary across sectors. Taking marginal productivities in the R sector as a base, we assume that the marginal products of labor and capital in sector i may be higher or lower by a factor of $1 + \delta_i$, where δ_i is an unknown constant that may take on any value, including zero. The equations underlying this assumption are the following:

$$\left(\frac{G_L}{R_L}\right) = \left(\frac{G_K}{R_K}\right) = 1 + \delta_g,\qquad(5)$$

$$\left(\frac{M_L}{R_L}\right) = \left(\frac{M_K}{R_K}\right) = 1 + \delta_m,\qquad(6)$$

$$\left(\frac{E_L}{R_L}\right) = \left(\frac{E_K}{R_K}\right) = 1 + \delta_e,\qquad(7)$$

where the uppercase subscripts denote partial derivatives of the production functions with respect to the subscripted input.[6]

In this economy, aggregate output is given by

$$Y = G + M + E + R,\qquad(8)$$

where Y is real output or spending, and total inputs are

$$L = L_g + L_m + L_e + L_r,\qquad(9)$$

and

$$K = K_g + K_m + K_e + K_r,\qquad(10)$$

where L and K are the total labor and capital stocks in the economy.

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6. The implicit assumption is that the productivity differential δ is the same for labor, and capital is a simplification. It would be possible to develop a simultaneous equations model, based on the four sectoral production functions, taking into account separate productivity differentials and cross-externality effects, but it could not readily be estimated due to data limitations. Separate data would be needed for the capital stock and labor employed in the defense sector and for that used in the other sectors of the economy.

By manipulating the production functions of equations (1) through (4) and using equations (5) through (10), the following approximation for an aggregate growth equation can be derived (see the appendix):

(11)

$$\frac{Y'}{Y} = R_L \left(\frac{L}{Y}\right)\left(\frac{L'}{L}\right) + R_K \left(\frac{I}{Y}\right) + \left(\frac{\delta_m}{1+\delta_m} + R_M\right)\left(\frac{M'}{M}\right)\left(\frac{M}{Y}\right)$$

$$+ \left(\frac{\delta_e}{1+\delta_e} + R_E\right)\left(\frac{E'}{E}\right)\left(\frac{E}{Y}\right) + \left(\frac{\delta_g}{1+\delta_g} + \frac{M_G}{1+\delta_m} + \frac{E_G}{1+\delta_e} + R_G\right)\left(\frac{G'}{G}\right)\left(\frac{G}{Y}\right),$$

where a prime indicates differentiation with respect to time, and I is aggregate real investment spending in the economy. As is shown in (11), the coefficient of the defense sector variable $(M'/M)(M/Y)$ captures both the externality effect of the defense sector on the rest of the economy (R_M) and any difference in productivity between the two sectors (δ_m). Therefore, in this model, the effect of military expenditure on economic growth is viewed as the result of the combination of externality and productivity effects. The coefficient of the export sector variable has the same form. The coefficient of the nonmilitary government sector contains terms for the relative productivity of this sector (δ_g) and its externality effect on the rest of the economy (R_G), as well as terms involving the relative productivity of each of the defense and export sectors $(\delta_m$ and $\delta_e)$ multiplied by the appropriate nonmilitary government sector externality effect $(M_G$ and $E_G)$.

In general, the model as proposed is theoretically neutral with respect to the direction of all particular relationships. Standard macroeconomic theory predicts a positive relationship between economic growth, employment growth, and the investment ratio, providing that the marginal products of labor and capital are positive in the rest of the economy. However, there is no reason to expect that all investment will pay off in either the short or long term. It is plausible for investment to provide a drain as well as a boost to economic productivity. In a similar way, larger workforces are not necessarily more productive workforces. Economies of scale in the production process are not always linear, nor do they necessarily apply to the wage bill. On the other hand, the direction of the growth effects of the military, export, and nonmilitary government sectors depends on the signs of the terms contained in the respective coefficients. Because there is no theoretical basis for a priori assumptions about the externality effects and the relative productivities of labor and capital in these sectors, the direction of their growth effects is an empirical rather than a theoretical question.

One advantage of the formulation adopted in this study is that it is derived from macroeconomic theory that describes the supply constraints important in societies such as Greece. It also makes weak requirements of data that are often problematic in many countries. Moreover, with the use of some other assumptions, this framework leads to a specification that allows separate estimates of the externality effects and pro-

ductivity differentials.[7] On the other hand, the model makes the controversial assumption that governmental (military and nonmilitary) output is final as opposed to intermediate. Moreover, it ignores the demand sector by assuming that it stays in equilibrium with the supply constraints of the economy. Each of these weaknesses is important but does not outweigh the important contributions of this model.

EMPIRICAL RESULTS

Simplifying the notation and adding a constant term and a stochastic component to equation (11), the growth-defense relationship takes the form

$$y_t = b_o + b_1 l_t + b_2 i_t + b_3 m_t + b_4 e_t + b_5 g_t + u_t, \tag{11'}$$

where y stands for the output growth rate, l for the growth rate of labor, i for the investment share, m for the defense sector variable, e for the export sector variable, and g for the nonmilitary government sector, with $b_1 = R_L(L/Y)$, $b_2 = R_K$, and the remaining coefficients representing the respective terms of equation (11). Equation (11') is used throughout the empirical work of this article.

All data are obtained from the National Accounts of Greece, and the period covered runs from 1960 through 1993. The rate of growth of real GDP is taken as a proxy for Y'/Y. Like many other researchers, I use rate of population growth (p) in place of the rate of growth of the labor force.[8] Although somewhat unsatisfactory, the main advantage of using population data is that they are likely to be much better than labor force data for Greece. This procedure may be challenged, but it is unlikely to be too unreasonable because the period we are considering is relatively short to involve any major demographic changes. Real military expenditure has been deducted from real total government expenditure to obtain data for real nonmilitary government spending. Constant-price military expenditure, exports, and nonmilitary government spending data are used to derive annual rates of change of these variables. Also, constant-price series are used to compute the ratios of the relevant variables to output.

As Engle and Granger (1987) point out, if the concept of equilibrium is to have any meaning or relevance, the processes underlying the relationship between the output growth rate and its determinants in equation (11') should be such that the "disequilibrium errors" u_t should tend to fluctuate around their mean values or show some systematic tendency to become small over time. A minimal condition for equilibrium is that the variables in the equilibrium relationship should be cointegrated. Otherwise, the disturbances will be nonstationary, and either relevant variables are missing, or a sub-

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7. Assuming that the output of the rest of the economy is affected by the other sectors with constant elasticities, equation (11) leads to a specification capable of producing separate estimates of the externality effects and productivity differentials. However, any attempt in the literature to estimate this equation has produced insignificant estimates of the different effects due to the presence of the severe multicollinearity problem.

8. See, for example, Feder (1982), Kormendi and Meguire (1985), Ram (1986, 1987), Grier and Tullock (1989), Levine and Renelt (1992), and Alexander (1990, 1995).

set of the variables are cointegrated and the remainder are included by mistake (Holden and Thompson 1992). For a set of variables to be cointegrated, it is necessary that (a) the individual series should be integrated to the same order, and (b) the residuals from fitting the postulated relationship should be integrated to a lower order than the individual series (Engle and Granger 1987).

As far as our data are concerned, the relevant Dickey-Fuller (DF) and augmented Dickey-Fuller (ADF) tests for unit roots and stationarity indicate that the hypothesis of a unit root in the variables included in equation (11′) cannot be rejected at least at the 5% level.[9] Therefore, the variables in question are integrated of order one [$I(1)$]. We then move to test the null hypothesis of noncointegration of the variables. If this hypothesis is rejected, equation (11′) is indeed a long-term equilibrium relationship.

To test the null hypothesis of noncointegration, equation (11′) is estimated by ordinary least squares (OLS). The regression results are as follows:

$$*** \qquad ***$$

$$y_t = -6.712 - 0.565\, p_t + 0.425\, i_t - 0.387\, m_t$$

$$(-2.802) \quad (-0.503) \quad (3.994) \quad (-0.351)$$

$$* \qquad **$$

$$+ 0.439\, e_t + 1.209\, g_t$$

$$(1.417) \quad (2.269)$$

$$\overline{R}^2 = 0.582,\ \text{SEE} = 2.333,\ \text{CRDW} = 2.423,\ F = 10.208$$

$$\text{AR}(2) = 4.713,\ \text{ARCH}(1) = 6.520,\ \text{RESET} = 0.610,\ \text{NORM}(2) = 1.652$$

where t values are in parentheses, *** denotes significance at the 1% level, ** denotes significance at the 5% level, and * denotes significance at the 10% level. $\overline{R}^2$ is the coefficient of determination adjusted for degrees of freedom, SEE is the standard error of the regression, CRDW is the cointegrating regression Durbin-Watson statistic, F is the regression F statistic, AR(2) is the second-order x^2 test for residual autocorrelation, ARCH(1) is the second-order x^2 test for autoregressive conditional heteroskedasticity, RESET is the F test for functional misspecification, and NORM(2) is the skewness and excess kurtosis x^2 test under the null hypothesis of normality.

Strictly speaking, it is not possible to draw any statistical inferences from these results. Because the series are nonstationary, useful tests such as the F and t statistics do not follow the standard distributions. Even the parameter estimates may not be unbiased, though they are consistent. However, although not strictly legitimate from the econometric point of view, we can interpret the coefficient estimates of the above regression equation as representing structural parameters (Engle and Granger 1987).

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9. The results of the relevant tests are available on request from the author.

The estimated equation is reasonably well defined in terms of the standard criteria as they are reported therein. The AR, ARCH, RESET, and NORM statistics do not provide evidence for rejecting the null hypotheses of no autocorrelation, homoskedasticity, no functional misspecification bias, and normality. The coefficient related to investment share is positive and significant at the 1% level, whereas the coefficients associated with population growth and the defense sector variable are negative and nonsignificant. Furthermore, the terms for the export sector and the nonmilitary government sector variables exhibit positive coefficients, which are significant at the 10% and 5% levels, respectively. However, as mentioned above, these results cannot be used for statistical inference about the growth effects of military expenditure in Greece. The estimated relationship is primarily used for cointegration testing purposes. To this end, two tests are used: the CRDW statistic (Engle and Granger 1987) and the ADF statistic (Davidson and Mackinnon 1993). The CRDW statistic is 2.423, indicating that the variables in question are cointegrated.[10] However, because Engle and Granger themselves suggest that the CRDW test might be used only for a quick approximate result, and DeJong et al. (1992) have shown that the ADF test outperforms most alternatives, we move to the second test, which is based on the residuals from fitting equation (11′). The regression equation run was of the form

$$\Delta u_t = -\varphi u_{t-1} + \sum_{i=1}^{z} \lambda i \, \Delta u_{t-i},$$

where u_t stands for the estimated residuals of equation (11′). Because the coefficient of u_{t-1} is significant at the 5% level ($t = -3.392$), the null hypothesis of noncointegration is rejected.[11] Therefore, the ADF statistic and the CRDW statistic provide enough indications in favor of cointegration that we may assert that equation (11′) does describe a long-run equilibrium relationship (Engle and Granger 1987).

Having established that the variables of interest are cointegrated, we pursue a general-to-specific methodology in line with prevalent practice (see Harvey 1981). In other words, we proceed with a general estimated equation that is consistent with the propositions depicted in equation (11′) and gradually impose parameter restrictions to find our preferred equation—namely, one that describes our data generation process most parsimoniously. Equation (11′) is estimated by the OLS method over the period from 1960 to 1993 using the following general ADL ($n, k:m$) form:

$$y_t = a_o + \sum_{i=1}^{n} a_i y_{t-i} + \sum_{k=1}^{m} \sum_{i=o}^{n} b_{ki} x_{k, t-i} + u_t,$$

where y is the dependent variable, x_k is the kth explanatory variable, and u_t is a white noise disturbance. Due to sample size limitations, two lags are introduced in each of the dependent and the explanatory variables. Nonsignificant lags are excluded on the basis of the F test and the likelihood ratio test for the validity of exclusion restrictions. After an efficient specification search, the more parsimonious representation is the following:

10. Critical values for this test are provided in Engle and Granger (1987).
11. Critical values are provided in Engle and Granger (1987).

$$
\overset{***}{} \qquad \overset{***}{} \qquad\qquad \overset{**}{}
$$

$$
y_t = 3.637 - 0.366(y_{t-1} - y_{t-2}) + 3.166(p_t - p_{t-1})
$$

(5.787) (−2.711)   (1.931)

$$
\overset{***}{} \qquad\qquad \overset{**}{} \qquad\qquad \overset{**}{}
$$

$$
+ 0.830(i_t - i_{t-2}) - 2.030(m_t - m_{t-1}) + 0.874e_{t-1}
$$

(4.575)   (−1.948)   (1.796)

$$
\overline{R}^2 = 0.422,\ SEE = 2.744,\ F = 5.827,\ AR(2) = 14.823
$$

$$
ARCH(1) = 0.274,\ RESET = 0.850,\ NORM(2) = 0.339
$$

The estimated equation appears to be satisfactory on statistical grounds. The statistics reported therein indicate that the equation is free of conventional problems except serial correlation. The negative coefficient of the lagged output growth rate term reflects a kind of "fatigue" element in the growth process of the Greek economy that can be explained by the high growth rates of the 1960s. The coefficient of the population growth term turns out to be positive and significant at the 5% level, which accords well with neoclassical growth theory. The coefficient of the investment-output ratio remains positive and significant, suggesting that investment is likely to have a short-term benefit in the output growth rate of Greece compared, for example, with negative effects for France (Fontanel 1990) and the United States (Ward and Davis 1991). The negative coefficient of the defense sector variable turns out to be significant at the 5% level, lending support to the hypothesis that military expenditure retards economic growth in Greece. In line with Ram's (1987) results, Greek data suggest that the role of exports is positive in this country. Finally, no term appears in the estimated equation for nonmilitary government expenditure. This result is not surprising given the inefficiency characterizing most government operations in this country.

Overall, the results suggest that military expenditure hinders economic expansion in Greece. This conclusion is not surprising given the positive growth effect of exports and the poor export performance of this country (during the period from 1960 to 1995, the average annual share of Greek exports to GDP was 12.6% compared to an EU average of 24.8%). In fact, these conditions might explain why the growth-defense relationship is positive in some countries and negative in others. Because military expenditure is often foreign exchange intensive, in foreign resource-constrained countries, defense is maintained or increased using scarce foreign exchange taken from alternative productive investment. In these countries, the game is zero-sum, and an increased defense effort might result in negative growth. For the foreign resource-unconstrained countries, on the other hand, an overall positive relationship between growth and defense might exist because the game is not zero-sum. In these countries, defense can be maintained or increased without syphoning off resources from more productive uses.

An explicit mention in regard to the structure of the estimated growth equation appears necessary in this respect. The Turkish invasion of Cyprus in 1974 as well as the

disputes between Greece and Turkey over the Aegean Sea's continental shelf, the width of Greek territorial waters, and Greece's airspace limits have created a strategic environment that might have adverse effects on the growth process of the Greek economy in the post-1974 period.[12] On one hand, the threat of war causes uncertainties and dangers that do not augur well for investment and growth. On the other hand, it is easier to mobilize and harness resources for investment in threat of wartime than in peacetime (Gyimah-Brempong 1989). However, the threat of war is not the only cause of a possible structural break around this time. The Greek economy underwent many changes due to the oil-price shocks of the 1970s that affected growth prospects during the subsequent period. Therefore, a possible change in the structure of the growth process of the Greek economy in after the mid-1970s should be interpreted with caution. To investigate a possible change in the structure of the estimated growth equation, equation (11') was reestimated separately for the subperiods from 1960-1973 and 1974-1993. The regression results are as follows:

Period 1960-1973:

$$y_t = 5.084 - 0.461\overset{***}{(y_{t-1}} - y_{t-2}) + 8.897\overset{***}{(p_t} - p_{t-1})$$

$$(5.267) \quad (-3.947) \qquad\qquad (3.532)$$

$$+ 1.146\overset{***}{(i_t} - i_{t-2}) - 7.622\overset{***}{(m_t} - m_{t-1}) + 1.324\,\overset{*}{e}_{t-1}$$

$$(3.864) \qquad\qquad (-3.381) \qquad\qquad (1.674)$$

$$\overline{R}^2 = 0.64,\ \text{SEE} = 1.767,\ F = 5.642,\ \text{AR}(2) = 2.504$$

$$\text{ARCH}(1) = 2.458,\ \text{RESET} = 0.476,\ \text{NORM}(2) = 0.489$$

Period 1974-1993:

$$y_t = 1.587 - 0.206\overset{*}{(y_{t-1}} - y_{t-2}) + 3.246\overset{**}{(p_t} - p_{t-1})$$

$$(3.145) \quad (-1.542) \qquad\qquad (2.451)$$

$$+ 0.273\overset{*}{(i_t} - i_{t-2}) - 2.908\overset{***}{(m_t} - m_{t-1}) + 0.834\overset{**}{e}_{t-1}$$

$$(1.729) \qquad\qquad (-3.902) \qquad\qquad (2.453)$$

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12. An overview of the main issues of friction between the two countries can be found in Wilson (1979); Clogg (1991); Larrabee (1992); Georgiou, Kapopoulos, and Lazaretou (1996); and Kollias (1996).

$$\overline{R}^2 = 0.55, \text{SEE} = 1.628, F = 5.704, \text{AR}(2) = 1.005$$

$$\text{ARCH}(1) = 0.379, \text{RESET} = 1.140, \text{NORM}(2) = 0.751$$

The equations appear to be satisfactory on the usual criteria as they are reported therein. We tested the null hypotheses

$$H_o^1 : b_{i,\,1960-1973} = b_{i,\,1974-1993} \text{ and } H_o^2 : \sigma^2_{1960-1973} = \sigma^2_{1974-1993}$$

that the parameters of the growth equation, including the constant term, and the error variances did not change between the two subperiods. The relevant test statistic for H_o^1 is $F = 8.777$ (Chow 1960), indicating that the parameter equality hypothesis is rejected; $F_{6,\,22} = 2.55$ (3.76) at the 5% (1%) level.[13] On the other hand, the test statistic for H_o^2 is $F = 0.848$ (Cuthbertson, Hall, and Taylor 1992), indicating that the error variances equality hypothesis cannot be rejected; $F_{14,\,8} = 3.23$ (5.56) at the 5% (1%) level.[14] We conclude that even though the error variances did not change, there was a change in the structure of the growth equation between the two subperiods. Estimation of the equation for the whole period with slope and shift dummies included indicated that parametric change might have occurred in the coefficients of some of the explanatory variables. To investigate this, we included only a shift dummy variable, W, which took the value 0 in the 1960-1973 sample and the value 1 in the 1974-1993 sample, and estimated our growth equation. The regression result is the following:

$$*** \quad *** \qquad ***$$

$$y_t = 6.130 - 0.322\left(y_{t-1} - y_{t-2}\right) + 3.564\left(p_t - p_{t-1}\right)$$

$$(9.822) \quad (-3.421) \qquad (3.127)$$

13. The test statistic is given by

$$F_{(K,N-2K)} = \cfrac{\cfrac{SSE_{1960-1993} - SSE_{1960-1973} - SSE_{1974-1993}}{K}}{\cfrac{\left(SSE_{1960-1973} + SSE_{1974-1993}\right)}{\left(N - 2K\right)}},$$

where the sums of squares of the least squares residuals are $SSE_{1960-1973} = 25.004$ and $SSE_{1974-1993} = 37.115$. For the regression equation of the two sets of data combined, $SSE_{1960-1993} = 210.828$, with $N = 34$ pooled observations and $K = 6$ parameters.

14. The test statistic is given by

$$F_{(n_2 - K, n_1 - K)} = \cfrac{\cfrac{SSE_{1974-1993}}{\left(n_{2-K}\right)}}{\cfrac{SSE_{1960-1973}}{\left(n_{1-K}\right)}},$$

where the sample sizes for the two subperiods are $n_1 = 14$ and $n_2 = 20$.

$$\underset{(3.615)}{***} \quad \underset{(-3.674)}{***} \quad \underset{(2.505)}{***} \quad \underset{(-5.583)}{***}$$

$$+ 0.502\left(i_t - i_{t-2}\right) - 2.691\left(m_t - m_{t-1}\right) + 0.846 e_{t-1} - 4.262 W$$

$$(3.615) \qquad\qquad (-3.674) \qquad\qquad (2.505) \qquad (-5.583)$$

$$\overline{R}^2 = 0.722,\ SEE = 1.903,\ F = 15.286,\ AR(2) = 0.483$$

$$ARCH(1) = 0.313,\ RESET = 1.691,\ NORM(2) = 1.475$$

Subsequently, we tested the null hypothesis that the slope variables did not contribute to the explanation of variations in Greek output growth rates. The relevant test statistic gives a value of $F = 2.530$,[15] and the tabulated value of $F_{5,22}$ at the 5% and 1% levels of significance are 2.66 and 3.99, respectively. Therefore, the null hypothesis is not rejected; that is, no parametric change has occurred in the coefficients of the explanatory variables. The coefficient of the dummy variable (and of every other variable) in the last equation is highly significant, suggesting that the change has occurred in the intercept. Moreover, its negative sign indicates that the growth process of the Greek economy has been retarded in the post-1974 period due to factors such as the threat of war and the oil-price shocks of the 1970s.

CONCLUSIONS

The evidence suggests that differences exist in both the intensity and the direction of the growth effects of military expenditure among countries. Therefore, most cross-sectional studies on the subject cannot offer useful insights into the growth-defense trade-off in specific countries. This study has used time-series analysis to investigate the impact of military spending on the output growth rates of the Greek economy over the period from 1960 to 1993.

A model has been developed in the context of the neoclassical production-function framework, which provides a formal rationalization for the incorporation of military expenditure in a growth equation. This framework postulates that the economy is made up of four sectors (military, nonmilitary government, exports, and rest of the economy), which are mutually exclusive and exhaustive with respect to output. Some

15. The test procedure uses the statistic

$$F_{(Q-L, N-Q)} = \frac{\dfrac{\left(SSR_Q - SSR_L\right)}{(Q-L)}}{\dfrac{SSE_Q}{(N-Q)}},$$

where Q is the number of the extended set of explanatory variables, including the slope and shift dummies; L is the number of explanatory variables in the estimated equation with the shift dummy only; and SSR is the regression sum of squares. The relevant values are $SSR_Q = 368.119$, $SSR_L = 332.388$, $SSE_Q = 62.120$, $Q - L = 5$, $N - Q = 22$.

sectors can be thought of as creating externalities on other sectors, and factor productivities may vary across sectors. These assumptions lead to an aggregate growth equation in which the effect of military expenditure on economic growth is viewed as the result of the combination of externality and productivity effects. We have used the technique of cointegration and the general-to-specific methodology in estimating this equation, and its more parsimonious representation showed that the annual output growth rate in Greece is positively affected by the population growth and the investment-output ratio and exports. The rate is affected negatively by the size of the defense sector, as measured by real military expenditure. Moreover, the results indicate that the growth process of the Greek economy has been retarded in the post-1974 period due to factors such as the threat of war and the oil-price shocks of the 1970s.

APPENDIX

This appendix presents the full development of the supply-side model analyzed above.

We assume that there are four sectors in the economy that are mutually exclusive and exhaustive with respect to output. We call these sectors M for military, G for nonmilitary government, E for exports, and R for the rest of the economy. Labor L and capital K are the main inputs to each sector, although some sectors can be thought of as affecting the output of other sectors positively or negatively. Given the analysis of the second section on externality effects, the production functions underlying the structure of the economy can be written as

$$G = G\,(L_g, K_g), \tag{A1}$$

$$M = M\,(L_m, K_m, G), \tag{A2}$$

$$E = E\,(L_e, K_e, G), \tag{A3}$$

$$R = R\,(L_r, K_r, G, M, E), \tag{A4}$$

where G, M, E, and R are real valued functions. Differentiating each of these equations, we get the following:

$$G' = G_L L'_g + G_K K'_g, \tag{A5}$$

$$M' = M_L L'_m + M_K K'_m + M_G G', \tag{A6}$$

$$E' = E_L L'_e + E_K K'_e + E_G G', \tag{A7}$$

$$R' = R_L L'_r + R_K K'_r + R_G G' + R_M M' + R_E E', \tag{A8}$$

where the lowercase subscripts denote the sectoral inputs of labor and capital, a prime indicates differentiation with respect to time (thus, $x' = dx/dt$), and the uppercase subscripts denote partial derivatives of the production functions with respect to the subscripted input.

Moreover, taking marginal productivities in the R sector as a base, we assume that the marginal products of labor and capital in sector i may be higher or lower by a factor of $1 + \delta i$. Thus, we assume that

$$\left(\frac{G_L}{R_L}\right) = \left(\frac{G_K}{R_K}\right) = 1 + \delta_g, \tag{A9}$$

$$\left(\frac{M_L}{R_L}\right) = \left(\frac{M_K}{R_K}\right) = 1 + \delta_m, \tag{A10}$$

$$\left(\frac{E_L}{R_L}\right) = \left(\frac{E_K}{R_K}\right) = 1 + \delta_e. \tag{A11}$$

Because by definition

$$Y = G + M + E + R,$$

it follows that

$$Y' = G' + M' + E' + R'. \tag{A12}$$

Substituting equations (5) through (8) into equation (12) and using equations (9) through (11) to eliminate G_L, G_K, M_L, M_K, E_L, and E_K, we have

$$Y' = (1 + \delta_g)R_L L'_g + (1 + \delta_g)R_K K'_g + (1 + \delta_m)R_L L'_m + (1 + \delta_m)R_K K'_m$$

$$+ M_G G' + (1 + \delta_e)R_L L'_e + (1 + \delta_e)R_K K'_e + E_G G' + R_L L'_r$$

$$+ R_K K'_r + R_G G' + R_M M' + R_E E'$$

expanding to

$$Y' = R_L\left(L'_g + L'_m + L'_e + L'_r\right) + R_K\left(K'_g + K'_m + K'_e + K'_r\right)$$

$$+ \delta_g\left(R_L L'_g + R_K K'_g\right) + \delta_m\left(R_L L'_m + R_K K'_m\right) + \delta_e\left(R_L L'_e + R_K K'_e\right)$$

$$+ M_G G' + E_G G' + R_G G' + R_M M' + R_E E'.$$

This simplifies even further if we note that

$$L = L_g + L_m + L_e + L_r,$$

$$K = K_g + K_m + K_e + K_r,$$

and

$$L' = L'_g + L'_m + L'_e + L'_r,$$

$$K' = I = K'_g + K'_m + K'_e + K'_r,$$

where I is the aggregate real investment spending in the economy. Thus,

$$Y' = R_L L' + R_K I + \delta_g \left(R_L L'_g + R_K K'_g \right) + \delta_m \left(R_L L'_m + R_K K'_m \right)$$

$$+ \delta_e \left(R_L L'_e + R_K K'_e \right) + M_G G' + E_G G' + R_G G' + R_M M' + R_E E'$$

(A13)

Using equations (9) through (11), we can transform the terms in the parentheses of the last equation into the following:

$$R_L L'_g + R_K K'_g = \frac{1}{1+\delta_g} G',$$

(A14)

$$R_L L'_m + R_K K'_m = \frac{1}{1+\delta_m} (M' - M_G G'),$$

(A15)

$$R_L L'_e + R_K K'_e = \frac{1}{1+\delta_e} (E' - E_G G').$$

(A16)

Substituting equations (14) through (16) into equation (13), we have

$$Y' = R_L L' + R_K I + \frac{\delta_g}{1+\delta_g} G' + \frac{\delta_m}{1+\delta_m} \left(M' - M_G G' \right) + \frac{\delta_e}{1+\delta_e} \left(E' - E_G G' \right)$$

$$+ M_G G' + E_G G' + R_G G' + R_M M' + R_E E'$$

$$= R_L L' + R_K I + \left(\frac{\delta_g}{1+\delta_g} + R_G + M_G + E_G \right) G' + \left(\frac{\delta_m}{1+\delta_m} + R_M \right) M'$$

$$- \frac{\delta_m}{1+\delta_m} M_G G' + \left(\frac{\delta_e}{1+\delta_e} + R_E \right) E' - E_G G'$$

$$= R_L L' + R_K I + \left(\frac{\delta_m}{1+\delta_m} + R_M \right) M' + \left(\frac{\delta_e}{1+\delta_e} + R_E \right) E'$$

$$+ \left(\frac{\delta_g}{1+\delta_g} + \frac{M_G}{1+\delta_m} + \frac{E_G}{1+\delta_e} + R_G \right) G'.$$

On dividing through by Y, this becomes

$$\frac{Y'}{Y} = R_L \left(\frac{L}{Y}\right)\left(\frac{L'}{L}\right) + R_K \left(\frac{I}{Y}\right) + \left(\frac{\delta_m}{1+\delta_m} + R_M\right)\left(\frac{M'}{M}\right)\left(\frac{M}{Y}\right)$$

$$+ \left(\frac{\delta_e}{1+\delta_e} + R_E\right)\left(\frac{E'}{E}\right)\left(\frac{E}{Y}\right)$$

$$+ \left(\frac{\delta_g}{1+\delta_g} + \frac{M_G}{1+\delta_m} + \frac{E_G}{1+\delta_e} + R_G\right)\left(\frac{G'}{G}\right)\left(\frac{G}{Y}\right).$$

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